BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Rationale for the Use of a Planetary Mission Module as an Earth Orbit Mission Module
Case 233

DATE: May 12, 1967

FROM: D. Macchia

ABSTRACT

One of the obvious requirements for a low cost integrated planetary and earth orbital space program is considerable commonality of hardware. In particular, the design of a multi-purpose planetary mission module is practical and represents a significant cost saving. With minor modification or additional design requirements the planetary module can also provide a sui able, cost-effective building block for earth orbital missions. This memorandum attempts to provide an economic and program evolution rationale for this development approach.

(NASA-CR-153867) RATIONALE FOR THE USE OF A PLANETARY MISSION MODULE AS AN EARTH ORBIT MISSION MODULE (Bellcomm, Inc.) 6 p

N79-71782

Unclas
00/12 12401

[redacted]

BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Rationale for the Use of a Planetary Mission Module as an Earth Orbit Mission Module
Case 233

DATE: May 12, 1967

FROM: D. Macchia

MEMORANDUM FOR FILE

Introduction

One of the obvious requirements for a low cost integrated planetary and earth orbital space program is considerable commonality of hardware. In particular, the design of a multi-purpose planetary mission module is practical and represents a significant cost saving. With minor modification or additional design requirements the planetary module can also provide a suitable, cost-effective building block for earth orbital missions. This memorandum attempts to provide the rationale for this development approach.

Economic Rationale

Any manned earth orbital experiment program involves the cost of:

1. transportation for experimental equipment into earth orbit,
2. equipment and mounting structure,
3. power for experiments,
4. data handling and transmission capability,
5. attitude control for experiments, and
6. crew time for experimentation.

The cost of providing crew time is by far the most expensive element. This is apparent when it is considered that most of the logistics and expensive hardware (i.e., large structure, EC/LS, power, entry module, real time communications, etc.) are necessary to support the crew.

[redacted]

Available crew time is also important from the scientist's viewpoint since the attainment of any given level of knowledge implies the expenditure of crew time on scientific equipment. In other words, knowledge or data is related to available crew time. It is not enough to simply transport equipment into orbit. Sufficient crew time must be provided to meaningfully utilize this equipment. For example, the MORL and Donlan studies have planned on an average of 2/3 man hours per pound of scientific equipment during one year of operation. If the goal of any earth orbital program is solely scientific experimentation, rather than the development of hardware for some other use, then a useful criteria of evaluation of the experimental program is the cost of crew time. In this sense crew time is considered linearly related to the knowledge gained.

It is interesting to consider current AAP plans to be representative of a first generation scientific space station. Limitations of crew time, power and data handling make the AAP station relatively inefficient. Experiment payloads will also be small (approximately 2,000-5,000 lbs.). But the DDT&E (design, development, test and engineering) costs of most of the hardware have been essentially paid for by Apollo. Additional DDT&E costs are required for a 90 day CSM, which would be desired in a one year program, and experiment support hardware. It is estimated that a 1 year 3 man AAP space station, including new DDT&E might cost in the vicinity of $800 million. Estimating 18 man-hours per day available for experimentation, the first year of AAP science would cost $120,000/man-hour. It is not clear that more than one year of crew time (or even less) would be worthwhile since the astronauts run out of things to do with the limited amount of scientific equipment. However, for purposes of discussion, an additional year with 3 resupply flights including new science equipment is assumed to cost $300 million resulting in a $84,000/man-hour over the two year period.

MORL scientific operations present a worthwhile comparison. In this case the DDT&E costs must be charged to the experimental program since the MORL is presumably incapable of any other use. Total MORL program costs plus 1 year's operation are estimated at $2.5 billion. With 16,700 man-hours available, MORL science costs $150,000/man-hour. Here again use of the MORL much beyond one year is questionable. It is stated in the MORL study that 14 months of 100% utilization of available crew time could complete the experimental program. We can assume again that additional science equipment could be resupplied with the next year's operation (at $425 million) and compute a 2 year crew time cost of $88,000/man-hour. Now it would take a 3 man AAP program 5 years to complete the MORL experimental program with additional science resupplied. This results in a 5 year AAP cost of $70,000/man-hour. Thus, AAP unit costs are quite competitive with MORL, but the quantity (and possibly value) of data gained will be lower because of less efficient equipment utilization.

Now if the basic MORL module and subsystems were suitable for planetary missions and DDT&E costs were assigned to a planetary mission, the program cost would be reduced by about $1 billion. Furthermore, since a mission module suitable for planetary missions has a 2-3 year lifetime requirement without resupply, logistics costs could be sharply reduced by say $300 million (down from $425 million). In addition, a significant amount of program management and crew training costs may be assigned to a planetary mission (say a $200 million reduction from $600 million). Hence, it is estimated that the total program costs plus 1 year of operation for an earth orbital program using a modified planetary module would be about $1 billion. Yearly operation costs of $125 million appear reasonable. On this basis a 2 year, 6 man program would come to $34,000/man-hour.

Program Evolution Rationale

At this point in time the likely course of space station evolution is not apparent. The limitations of AAP appear to make a larger interim station (of the MORL class) desirable. It has also been assumed in some quarters that a much larger multi-man operational station would be the next step after an interim station.

In general, orbital space programs have the following possible purposes:

1. Demonstration of long term space flight capability of both man and subsystems,
2. Accomplishment of experimental programs, and
3. Long term or continuous operational tasks which gather data for ground based user agencies or scientific purposes.

Long term flight demonstration is fairly well defined and could be easily accomplished by any 2 year program (if planned on). Experimental programs on the other hand vary considerably, but they are all finite in that some number of man years of experimentation is envisioned. After the initial experimental programs are completed the crew will then supposedly continue on further, but presently undefined experimental work and/or also commence operational tasks. It is the area of operational tasks that remains quite poorly understood. An operational task in general has definite data, crew time, and equipment requirements on a continuing basis and supports the activities of some ground based organization. Manned space based astronomy is an operational task since the experimental program can continue indefinitely whereas manned meteorology or earth resources may only be experiment programs which serve to define future unmanned systems.

An experimental program can be accomplished with a large station in a short time period or a small station in a long time period. As pointed out previously, the MORL can accomplish its initial experimental program in only 14 months. It would seem unwise to seriously consider the construction of large space stations until it is determined whether or not they can be effectively utilized after the initial experimental program at the level of activity they are designed for. Regarding operational use of space stations it is noted that other operational space systems such as weather and communications satellites are unmanned. It is hard to envision use of man in space with operational systems other than maintenance, calibration of sensors, film and filter changing, etc. The MORL spacecraft itself, which can be considered an operational system, has been estimated to require about .04 man-hours/pound of S/C for operation and maintenance. This compares with the 2/3 man-hours/pound for the experiment program. Consequently, an operational space station may require a smaller crew than an experimental program space station, with the astronauts performing merely short time services to the equipment.

A good experimental program would build upon the results of AAP but will be difficult to plan until these results are available. Current interim space station experiment plans probably include considerable duplication of AAP experiments, and at this point in time the interim space concept can only offer a bigger AAP experimental workshop. Operational systems which might materialize some of the economic benefits suggested possible by orbital operations are totally undefined. Any unique interim space station concept configured solely to perform an experimental program in optimum fashion rests on weak logical grounds unless it is a sensible, coherent evolution from AAP which offers some degree of economic return.

Waiting for definition of an orbital experiment program which would in turn place requirements on an orbital mission module, and then trying to use that mission module for planetary operations would seem to cause unnecessary planning delays and confusion. As pointed out previously an experiment program requires crew time, data handling and transmission, power, mounting structure, etc. Most of these requirements can be supplied by a planetary mission module if it is specified initially. An experiment mounting rack (or a module) would then be the only additional relatively low cost hardware development required for the experimental program. A combination mission module* and experiment rack can serve as a low cost interim space station suitable for any reasonable experiment program (as illustrated by the favorable comparison of AAP with MORL). This latter course of action would seem to be a more rational plan.

Summary

In summary:

1. The course of space station evolution is uncertain since the objectives of each space station depend to considerable degree on the scientific results of the preceeding station. It is not clear that an interim space station offers the promise of sufficient new features over an expanded AAP program to, in itself, justify such a new development. And finally, large multi-man operational space stations are unsupportable at this time.

2. The objective of the earth orbital experimental program is the accumulation of knowledge. This objective can be achieved at significantly less cost if a planetary mission module is used for experiment support rather than a unique interim experimental space station. In fact, AAP is competitive in cost with the interim station and does not require any major new development costs.

3. The planetary and earth orbital experimental programs can support one another if the planetary module is used as an orbital space station. In specific, a planetary program requires 2 years of orbital flight time within which time the astronauts must be kept busy. The orbital experiment program, on the other hand, must select the most cost-effective means of achieving its objectives.

D. Macchia

1013-DM-nmm D. Macchia

Copy to
(see next page)

---

*Power, propulsion and storage could be supplied by modules developed for the planetary program or some of those functions could be supplied by units integral with the mission module. The hardware is approximately similar for both missions.